january, 1960

nlgi spokesman

journal of the national lubricating grease institute

NLGI Annual Production Survey

Ten Years in Retrospect

By T. G. ROEHNER

Wear Rates in Chassis Lubrication (Passenger Cars)

By L. C. BRUNSTRUM and W. L. HAYNE, JR.

Sensory Examination of Lubricating Greases

By A. S. ORR (An NLGI SPOKESMAN Reprint)

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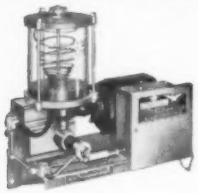

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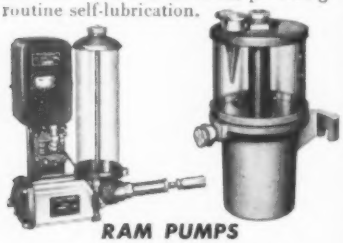

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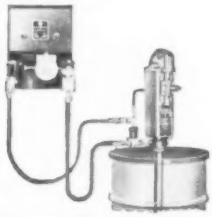

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THE COVER

THIS young lady has been on our cover before, for she illustrates the illuminated inspection plates mentioned in A. S. Orr's article on sensory examination, first published by NLGI in August, 1958. The very popularity of this subject soon exhausted the Institute's supply of back issues and reprints. A feature of particular interest because so many customers judge a lubricating grease by sight, smell and touch, Mr. Orr has proposed a standard vocabulary of terms for describing the sensory observations. We offer his suggestions for your consideration and convenience.

The NLGI SPOKESMAN is indexed by Industrial Arts Index and Chemical Abstracts. Microfilm copies are available through University Microfilm, Ann Arbor, Mich. The NLGI assumes no responsibility for the statements and opinions advanced by contributors to its publications. Views expressed in the editorials are those of the editors and do not necessarily represent the official position of the NLGI.
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NLGI PRESIDENT'S PAGE

By H. A. MAYOR, JR., *President*

A Plea for Help

All official representatives of NLGI active members have recently received the following letter. Because our Institute is trying hard to serve all segments of our industry, this same plea for assistance is hereby directed to the entire NLGI SPOKESMAN readership.

Dear Member:

Now that things are returning to normal after what was, for me, the most exciting NLGI Annual Meeting of them all, it becomes time to commence some hard-headed, realistic, accomplishable planning for the 27th Year of the Institute activity. In this area your help is badly needed.

Your Board of Directors started work on the new year of activity shortly after their election but perhaps the vision of this small group could be enlarged. It would help immeasurably if you could give some thought to the immediate and long range future and capabilities of the NLGI then drop me a note covering the ideas, suggestions, and criticism that will logically result.

You have my assurance that each communication received will be closely studied and evaluated. Subject, of course, to board review, enthusiastic follow-up of your ideas will be made. The NLGI can effectively serve our industry only with the help and under the direction of the entire membership. It's for this basic reason that your help is being requested.

May I take this opportunity to personally thank you for the opportunity of serving as your 27th President? It's a real honor for me and my company. The grease industry has been good to me and anything I can do to reciprocally serve the industry will be done.

In the spirit of the season, best wishes for a prosperous and Happy New Year.

Yours very truly,

H. A. MAYOR, JR.

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There's no middle man in the picture when you buy your hydrogenated castor oil derivatives from Baker. Because, from selection of the raw castor beans to production of the finished chemicals, Baker does it all.

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News About NLGI

Greif Joins NLGI

Greif Brothers Cooperage corporation, northern cooperage division, St. Paul, Minnesota, has joined NLGI as an Associate member. Mr. Ray Suttle, district manager in Winfield, Kansas, will be NLGI Company Representative, while Mr. A. H. Snipes, vice president in St. Paul, will act as Technical Representative. A feature on this new member organization will be offered in a later issue of the NLGI SPOKESMAN.

Strauf Is Representative

Darling & Company announce that L. Strauf will become NLGI Company Representative, replacing the late George W. Trainor, who died in early November.

Annual Audit Will Bring Questions

Members and friends of NLGI may receive inquiries in the mail next month from Arthur Anderson & Company, national accounting firm. The questions would deal with services rendered by NLGI and are part of the procedures taken each year during the annual audit of the national office and the office of the treasurer.

Audits were begun with the Institute in 1952 and have been continued through the years to insure the membership that records and finances are kept in a businesslike fashion.

Introducing Two New Members of the NLGI Board of Directors

Two new members of the NLGI board of directors elected at the recent annual meeting . . . the NLGI SPOKESMAN would like to introduce them to the membership:

Esso Standard Oil company's Company Representative is Mr. J. J. Coates, replacing Dr. J. V. Starr, former board member and secretary of the Institute, now deceased. Coates is manager of Esso's Pittsburgh plant. A graduate of Manhattan college with a BSE in 1936, he earned a MSE at New York university in 1939. He has been with Esso since 1944.

Sinclair Refining company's Company Representative is Mr. F. W. Minor, replacing the late A. S. Randak. Minor is manager, lubricating sales. A graduate of the University of Missouri in 1936, Minor began with Sinclair as a junior salesman. He has held a number of positions with his company and also served three years with the Navy, being awarded the Bronze Star.

Other board members, who have previously been introduced at the time of their elections include these re-elected Company Representatives: W. W. Albright from Standard Oil (Indiana), T. W. Binford from D-A Lubricants, G. Landis from Atlantic Refining, J. W. Lane from Socony Mobil Oil, G. E. Merkle from Fiske Brothers Refining, and W. M. Murray from Kerr–McGee Oil Industries.

Technical Committee Column

CHAIRMAN L. C. BRUNSTRUM

Standard Oil Company (Ind.)

Section Leader in Charge of Research on Greases and Industrial Lubricants

Now that the work of the Dispensing Panel has been completed, there is being formed a new Committee on Grease Dispensing in Central Systems. The general area of activity will cover industrial grease dispensing. We have been most fortunate in securing Messrs. C. F. Raisch of Stewart-Warner as Chairman and E. M. Higgins of Master Lubricants Company as Vice-chairman. With their experienced and dynamic leadership a meeting will soon be held to develop the scope and program. Participation by representatives in all classes of NLGI membership is cordially invited. Interested parties may contact them or the chairman or vice-chairmen of the Technical Committee.

Two NLGI Booklets . . .

"RECOMMENDED PRACTICES"

for Lubricating Automotive Front Wheel Bearings

—and—

for Lubricating Passenger Car Ball Joint Front Suspensions

FAMED throughout the world, both of these proved and valuable aids give the recommended practices for application of lubricants . . . for automotive front wheel bearings in NLGI's newest twelve-page booklet . . . and for passenger car ball joint front suspensions, a revised edition of the sixteen-page manual now in its sixth printing. Compiled by experts in the industry, these handy guides are clearly illustrated, with easy-to-read directions. They may be purchased with quantity discounts, and company advertising or public relations messages can be added at cost. Immediate attention will be given to all orders.

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CITY _____

STATE _____

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☐ Please send _____ of the above to:

COMPANY _____

STREET _____

CITY _____

STATE _____

Future Meetings

JANUARY, 1960

31-Feb. 5 ASTM, Committee D-2 Meeting, Statler Hotel, Detroit.

FEBRUARY, 1960

25 API Division of Marketing, Lubrication Committee Meeting, Sheraton-Park Plaza Hotel, St. Louis.

24 NLGI Board of Directors Meeting, Park Plaza Hotel, St. Louis.

MARCH, 1960

15-17 SAE National Automotive Meeting, Sheraton-Cadillac Hotel, Detroit.

23-24 Ohio Petroleum Marketers Assn., Annual Convention and Marketing Exposition. Deshler-Hilton Hotel, Columbus, Ohio.

APRIL, 1960

19-20 ASLE, Annual Meeting and Exhibit, Netherland–Hilton Hotel, Cincinnati.

20-22 API Division of Production, Rocky Mountain District Meeting, Gladstone, Henning, & Townsend Hotels, Casper

20-21 National Petroleum Association Spring Meeting, Sheraton Cleveland Hotel, Cleveland, Ohio.

MAY, 1960

18-20 API Division of Marketing, Midyear Meeting, Statler-Hilton Hotel, Cleveland

JUNE, 1960

5-10 Society of Automotive Engineers, summer meeting, Edgewater Beach Hotel, Chicago

SEPTEMBER, 1960

14-16 National Petroleum Association Annual Meeting, Hotel Traymore, Atlantic City, New Jersey.

OCTOBER, 1960

17-19 ASME – ASLE Lubrication Conference, Statler Hilton Hotel, Boston.

30-Nov. 1 NLGI Annual Meeting, Edgewater Beach Hotel, Chicago.

NOVEMBER, 1960

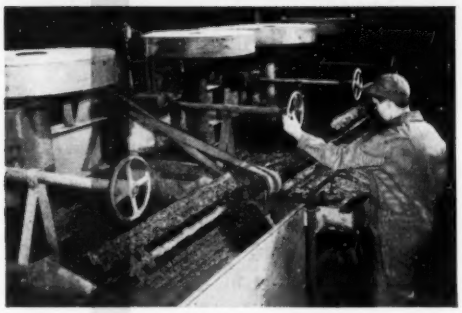
27-Dec. 2 ASME Annual Meeting, Statler Hilton Hotel, New York.

ADVANTAGES
of membership in the
National Lubricating Grease Institute

Some of the membership advantages are listed below:

- The NLGI represents over 95 per cent of the lubricating grease industry with members in this country and overseas.
- NLGI has a Technical Committee of 154 members which is divided into nine sub-committees working constantly on industry problems.
- The NLGI SPOKESMAN, a monthly technical journal, is mailed free of charge to key personnel within a member firm. If extra copies of the magazine are needed, they may be purchased at half the regular subscription price.
- The Institute works in close cooperation with affiliated groups including SAE, ASTM, ASA, ASLE, ASME, SAE-Cimtc and IOCA on problems and accomplishments in the lubricating field.
- The main objectives of the National Lubricating Grease Institute are for the development of better lubricating greases for the consumer and better grease lubrication engineering service to industry.

If your firm is interested in becoming affiliated with NLGI, the national office will be happy to furnish further information concerning the organization. Just as 1959 was a banner year for NLGI accomplishments 1960 promises to be even better with more scope and more member advantages.



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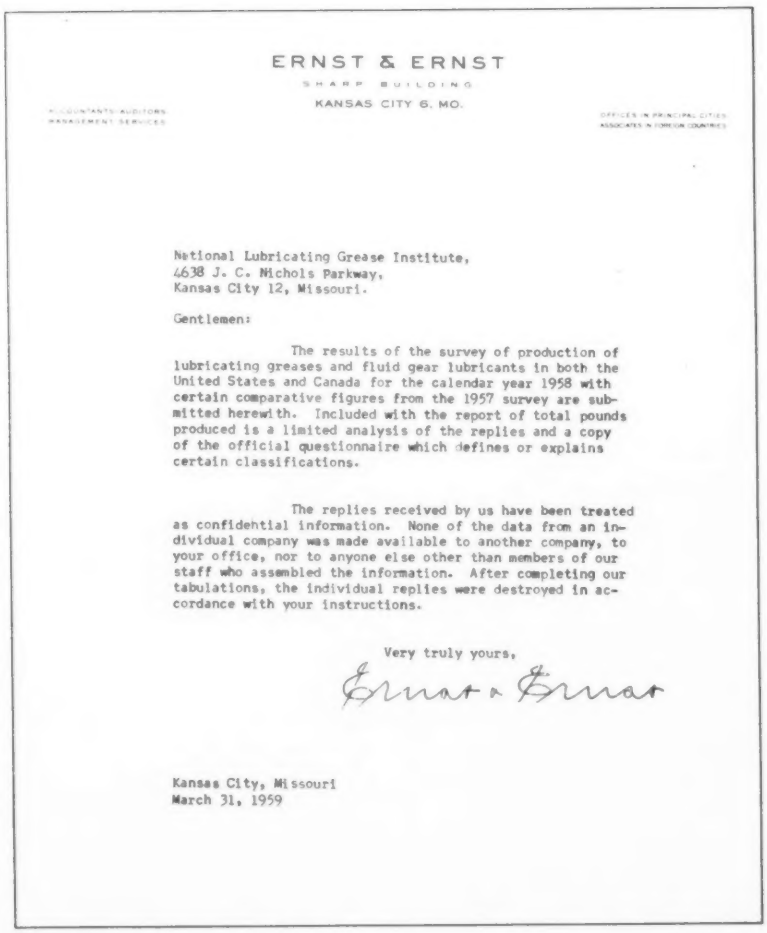
1959 SURVEY

Production Data Will Again Be Collected, in the Only Industry Gathering of This Nature



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Gentlemen:

The results of the survey of production of lubricating greases and fluid gear lubricants in both the United States and Canada for the calendar year 1958 with certain comparative figures from the 1957 survey are submitted herewith. Included with the report of total pounds produced is a limited analysis of the replies and a copy of the official questionnaire which defines or explains certain classifications.

The replies received by us have been treated as confidential information. None of the data from an individual company was made available to another company, to your office, nor to anyone else other than members of our staff who assembled the information. After completing our tabulations, the individual replies were destroyed in accordance with your instructions.

Very truly yours,

Ernst & Ernst

Kansas City, Missouri
March 31, 1959

The third annual survey on production of lubricating greases and fluid gear lubricants will be taken next month, when all NLGI Active (manufacturing) members receive questionnaires for pounds produced during the calendar year of 1959, in both Canada and the United States.

An estimated 85 percent of total U. S. production has been shown in the two previous surveys (1957 and 1958), with the percentage of U. S. Actives replying averaging about 75 per cent of the Institute's possible American response. Canadian response was 100 percent in their first compilation, last year.

Forms are mailed in January and compiled in late March. In mid-April, results are mailed to the entire membership—all four classifications.

Although there is a committee assigned to study and seek ways to improve the survey each year, there will be no changes in the form for the 1959 gathering . . . it will be identical to the form employed for the 1958 data. The committee is considering several steps to enlarge the service performed, however, and these will be reviewed before the membership in the year to come.

Handling of the survey procedures will be identical, too. Because of the success in maintaining complete anonymity, the management services division of the nation-wide certified public accounting firm of Ernst & Ernst will again conduct the actual compilation. The several steps taken include (1) a sample mailing from the NLGI office in mid-December to re-acquaint Actives with the forms used. In January (2), Ernst & Ernst sends the actual questionnaires to the Company Representative of each Active firm, by registered mail. After com-

piling the total poundage manufactured the Active then (3) returns the completed questionnaire to Ernst & Ernst. Because there is no way of knowing those companies which might have already replied and those which might be late, a general follow-up mailing reminder (4) to all Actives will come from E&E in early March. By month's end the totals are taken and survey results (5) are rushed to the overall membership in mid-April.

All replies received by Ernst & Ernst are treated as confidential information. None of the data is released, except in the final totals, nor is any one company recognizable. After tabulations are completed, all replies are destroyed.

This careful procedure has earned the Institute a return figure which is considered excellent . . . averaging about 75 per cent in the two years. Special emphasis will be given by the officers and the board of directors of the Institute however, to induce the remaining U. S. companies to submit their figures. For although the percentage not reporting is estimated at only 15 per cent of production, the final survey figures would have still more meaning if every firm participated.

Value of the final data is growing progressively from a historical standpoint . . . the comparison of figures reported between 1957 and 1958 is now indicative of trends, which can be confirmed again when the 1959 report is submitted. All Company Representatives of Active member firms who might not have answered in the previous years are urged to consider participation for the 1959 gathering, rendering this Institute service of even more value.

SUMMARY OF TOTAL POUNDS PRODUCED — UNITED STATES
1958 and 1957

	Pounds Produced		*Per cent*	
LUBRICATING GREASES	1958	1957	1958	1957
1. Aluminum Soap	21,275,526	27,142,543	3.97%	4.66%
2. Calcium Soap	179,708,385	218,844,369	33.56	37.61
3. Lithium Soap	182,457,197	160,462,383	34.07	27.58
4. Sodium Soap	113,570,809	128,859,083	21.21	22.15
5. Other Soap	19,874,925	28,680,446	3.72	4.93
6. Non-Soap (Inorganic Thickener)	18,597,992	17,891,004	3.47	3.07
Grand Total of Lubricating Greases	535,484,834	581,879,828	100.00%	100.00%

TOTAL POUNDS OF FLUID GEAR LUBRICANTS PRODUCED

Pounds Produced	
1958	1957
495,298,609	473,999,270

SUMMARY OF TOTAL POUNDS PRODUCED — CANADA
1958

	Pounds Produced	*Per Cent*
LUBRICATING GREASES	1958	1958
1. Aluminum Soap	288,785	.88%
2. Calcium Soap	17,602,914	53.88
3. Lithium Soap	2,454,451	7.51
4. Sodium Soap	9,598,733	29.38
5. Other Soap	1,622,340	4.97
6. Non-Soap (Inorganic Thickener)	1,105,297	3.38
Grand Total of Lubricating Greases	32,672,520	100.00%

TOTAL POUNDS OF FLUID GEAR LUBRICANTS PRODUCED 31,963,603

ANALYSIS OF REPLIES

Total active members mailed questionnaires	6
Total replies received	6
Per cent return	100.00%

Presented at the NLGI 27th annual meeting in New Orleans, October, 1959

NLGI's Technical Committee Chairman for Twelve Years, T. G. Roehner, Steps Down from The Position and Takes a Look At the Industry's Last Decade With His Recollections of . . .

TEN YEARS IN RETROSPECT

THE CONSTITUTION OF NLGI states that two purposes of the Institute shall be:

1. To act as a clearing house for the collection of lawful information pertinent to the manufacture and use of lubricating grease and to disseminate such information to manufacturers, marketers and consumers of lubricating grease and to the public.

2. To promote the advancement of research and practical tests in the field of lubricating grease manufacture and its use.

This review of technological advances within the lubricating grease industry during the past ten years will lead to the conclusion that NLGI has served the industry well in accordance with those objectives. Our fundamental knowledge about grease structure, manufacture and use has been expanded to a notable extent. This can be credited in large measure to the stimulation of NLGI's technical programs. NLGI's programs have been alert to the commercial implications of new fundamental knowledge and have aided in making this knowledge commercially useful.

Today's technical problems demand so much attention that they may crowd out references to past but related events. Thus, we often are not fully aware of how indebted we are to valuable data and ideas previously reported, nor do we always take full advantage of them for use as background for today's efforts. With this in mind, a quick look at the Index of Volume 12, April '48 to March '49 of the NLGI SPOKESMAN will be interesting because it will show papers by H. M. Fraser and F. W. Spooner on "Multi-Purpose Automotive Greases," by L. C. Brunstrum on "The Light Weight Cone for Penetration of Soft Greases," and by C. W. Georgi on "The Effect of Inorganic Fillers on Wear of Anti-Friction Bearings." The data and conclusions con-

tained in those papers have a direct bearing on problems which will be discussed during this New Orleans meeting and we can expect that our discussions this week may be the basis for solid accomplishments—in turn leading to new problems which will be subjects for new discussions ten years hence.

The lubricating grease industry, like many other industries, spurted ahead at an accelerated rate during World War II. There was an increased appreciation of the need for research to guide the development of new products to meet new exacting requirements. During the past ten years, research efforts have continued to increase to a noteworthy extent. The manpower and research budgets of leading manufacturers of lubricating greases have, in most cases, more than doubled, and are reported in hundreds of thousands of dollars. One measure of that growth is the number of U. S. patents on lubricating greases issued during those periods. In the ten-year period between 1930 and 1940, the total was about 69. In the next decade, the total increased to about 215, and in the nine and one-half year period of 1950 to 1959, it was about 409.

Evidence of the productivity of this intensive research effort is spread over all of the phases which must be coordinated before the final results are put to work in the consumers' bearings. For example:

1. new research tools and techniques
2. new raw materials
3. new manufacturing equipment
4. new laboratory evaluation and control instruments and methods
5. new application techniques
6. new and improved packages

have all raised the performance quality levels and the uniformity of maintenance of those levels to the point where the yardsticks used for judging the potentials of grease lubrication ten years ago are no longer adequate and must be expanded to an important degree for the next ten-year period.

One illustration of the strides we have made is a comparison of the most stringent government specifications for bearing life tests then and now. Ten years ago, no government specification required more than 1000 hours bearing life at 250°F whereas a current specification calls for 500 hours at 450°F and a Coordinating Research Council committee is developing test equipment to evaluate greases at 700°F under load.

Another example is the development of multi-purpose greases which have EP characteristics formerly limited to special greases.

Let's examine some of the major advances in each of the six phases mentioned above.

1. New Research Tools and Techniques:

The electron microscope has become a conventional research tool in those laboratories studying the basic structures of greases. Yet, B. B. Farrington and D. H. Birdsall's paper on "An Electron Microscope Study of Lubricating Greases," the first on this subject, was published as recently as the April 1947 issue of the NLGI SPOKESMAN. It has opened a number of doors which had blocked real progress. Perhaps the easiest way to indicate the importance of this instrument is to state that certain models are capable of magnifying one square inch to an equivalent approaching one square mile, or, in other words, it enables a laboratory to almost see the separate molecules responsible for the grease structure.

Other research tools, such as the infra-red spectrometer and x-ray diffraction, are now used for specific problems. More recent developments seem to indicate that electron diffraction will find increasing use in studies of grease structure.

It is a healthy sign that NLGI has continued to maintain a close interest in progress in research on the basic structure of greases. In 1951, an NLGI Research Fellowship was established at the University of Southern California under Dr. R. D. Vold. It was maintained there for five years and during that period, Dr. Vold and his associates published such papers, in the NLGI SPOKESMAN, as "Grease Structures Indicated by X-Ray Orientation Analysis and Electron Microscopy." The current NLGI Research Fellowship is located at Utah University. It was started in 1956 under Dr. Henry Eyring in the field of rheology or flow properties of greases, another subject which is of fundamental im-

About the Author

T. G. ROEHNER, *manager, technical service division, Socony Mobil Oil company, has served for twelve years as NLGI's technical committee chairman. A change in responsibilities brought his resignation. He was one of the first two men honored by the Institute's "Award for Achievement" and has long been considered one of the guiding lights of NLGI in the field of technical development and research progress.*

portance to the entire industry.

In addition to providing a forum and a journal for publication of individual reports on progress on grease research studies, the NLGI has held several symposia on grease characteristics, structure and flow properties. In 1954 at San Francisco, a symposium on "Studies of Grease Structure—A Basis for New Developments" was held. In 1955 another on "Flow Properties of Lubricating Greases" and in 1957 "Fundamental and Practical Aspects of Bleeding of Lubricating Greases" were covered. Last year a second symposium was held on flow properties of grease in view of the rapid development of our knowledge and the importance of this field. The interchange of data, theories and ideas at these symposia stimulates interest in further research work, cuts down on duplication of effort and can lead to a leapfrogging effect in our fundamental knowledge. In 1957, the Technical Committee on Fundamental Research was organized within the NLGI to ensure continual attention to the key importance of grease research.

2. New Raw Materials:

Under the heading of new raw materials available for formulation of improved lubricating greases, remarkable progress has been made in all three major components, i.e., thickeners, the fluid phase in which the thickeners are dispersed and additives for increasing chemical and structural stabilities, and wear and rust prevention. These have enabled the formulation of multi-purpose greases with broader ranges of application to keep in step with widening consumer requirements.

Ten years ago, greases were limited to operating temperatures of about minus 65°F to plus 400°F. Today, special greases particularly for military equipment permit extension of this range from minus 100°F to plus 600°F.

Ten years ago, radiation resistant fluids and thickeners were of no concern. Today, we are on the threshold of a considerable demand for special greases resistant to high doses of radiation.

Among the new raw materials which have made their mark during the past few years are:

1. Complex soaps
2. Non-soap thickeners, e.g., clays, silica and organics (copper phthalocyanine, aryl ureas, terephthalamates and pigments).
3. Modified silicones and esters and polyphenylethers
4. Solid lubricants, such as molybdenum disulfide.

Along with the new materials has come a better understanding of phase and colloidal changes which occur in the more conventional soap-oil systems as a fuction of temperature and soap environment.

3. New and Improved Manufacturing Equipment:

The pressure for reduction in manufacturing costs, the use of new thickeners and additives and the need for improvements in uniformity of quality of greases as shipped to consumers has led to introduction of radically new equipment in grease plants as well as improvement of older types. Ten years ago, most grease plants saponified in pressure kettles or even open kettles. During the past ten years, many of them have installed contacting equipment which markedly improves mixing and heat transfer during the soap-making stage with a favorable effect on quality of production and a reduction in time for this manufacturing step.

Ten years ago, the use of homogenization as a step in grease processing was just beginning. Now, this is a routine step in the manufacture of many greases to improve soap dispersion and in the case of some new thickeners, it is essential for the formation of a stable grease structure. During the past ten years, we have also witnessed a large increase in the use of deaeration equipment to improve product uniformity and quality. For the same reasons, filters are now used more widely and the filters themselves have been improved.

New types of equipment for speeding the cooling of grease during the finishing process have been introduced in the past ten years. This, together with improved raw material quality control plus proper layout and integration of equipment, has led to semi-continuous grease manufacture for some large volume products.

Process control for batch and continuous manufacture has been tightened. The use of automatic temperature and pressure recorders is widespread.

In order to keep handling costs down, new techniques for storage and moving of raw materials and finished products have been introduced. Some of these, like hopper feeding, are specific to particular grease plant layouts while the use of pallets and palletizing equipment is now practically universal.

The efficient, up-to-date plant is a far cry from the plant considered satisfactory ten years ago and there is good reason to expect further engineering advances during the next period.

4. New and Improved Methods for Laboratory Evaluation of Lubricating Greases:

The fourth area for technological progress is the development of improved laboratory methods for evaluating lubricating greases. This area has received the most publicity because it is connected with the activities of organizations such as ASTM Technical Committee G and the Aviation Fuel, Lubricant and Equipment Research Committee of the Coordinating Research Council. Progress under the three headings already covered is often the result of work by technical personnel within supplier industries coordinated with

that of laboratories of grease manufacturers. The evolution of laboratory test methods differs in that it is frequently characterized by participation by technical personnel of the consumers. Furthermore, it is often associated with the setting up of specifications intended to define performance characteristics of greases under service conditions.

During the past ten years, there has been a trend toward development of so-called functional testers. One of the pioneers of this type is the Wheel Bearing Grease Tester covered by ASTM Method D1263-53T. This trend has stemmed from recognition of the fact that satisfactory performance in a bearing under a specified range of operating conditions is usually dependent on a happy combination of a number of characteristics and that the comparatively empirical tests as, for example, worked penetration and dropping point tests, furnish only directive information. NLGI made its contribution to a better understanding of the pros and cons of the latter by providing for forums such as the 1955 Panel Discussion on the lubrication of modern farm machinery and by promoting interchanges of technical information in the early 1950's through joint committees with the Anti-Friction Bearings Association and the American Railroad Association. Papers published in the NLGI Spokesman helped to explain to users why it is incorrect to assume, for example, that two greases having the same ASTM worked penetration at 77°F will have the same consistencies at 30°F and/or 150°F and why ASTM drop points do not give a reliable indication of chemical stability at high temperatures.

This may be the opportune time to mention the progress made by our Technical Committee working on definitions for terms peculiar to the lubricating grease industry. The more terms they define, the more controversy they stir up—which is a strong pointer to the need for that work. They have already published 30 definitions in the NLGI Spokesman and have another list of fifteen to offer during this meeting. Many of these terms relate in some way to the language used in test methods and should be of particular value to consumers.

NLGI is helping to point out that while functional testers are useful for screening, actual service in the field is necessary before the full potentialities and limitations of a grease can be reliably determined. Data from such testers, particularly if the test conditions are accelerated, are also subject to serious misinterpretation.

5. New and Improved Packaging:

Grease packaging has also undergone notable changes during the past ten years. Standard-sized containers have been proposed and generally accepted throughout the industry. In the past few years, the use of grease cartridges has been introduced and widely accepted, particularly in the farm market. A recent development about which we will hear more later is bulk grease shipment.

6. New and Improved Methods of Application:

Finally NLGI has made important contributions particularly in the area of application of greases to automotive front-wheel bearings and to ball joints of front suspensions. In respect to the former, confusion was caused by the fact that each car manufacturer recommended a different procedure for care of wheel bearings. In 1951 NLGI organized a committee to study this problem and in 1954 they published NLGI's *Recommended Practices for Lubricating Automotive Front Wheel Bearings*. Over 150,000 copies have been sold to date and another printing was required this year. This committee is still actively working on possible simplifications.

In 1956, a similar study was started regarding lubrication of ball joints of passenger car front suspensions and in 1959 NLGI's recommended practices for this operation was published in the NLGI Spokesman.

NLGI has pioneered in the study of methods for rating grease dispensing equipment in terms of the apparent viscosities of the greases to be delivered to the bearings. The committee working on this problem was organized in 1948 and its membership includes representatives of leading manufacturers of dispensing equipment who are associate members of NLGI. After many expensive runs by each member under a range of conditions, sufficient technical data were obtained to warrant publication of the tentative NLGI Method for Matching Grease Flow Properties with Grease Dispensing Pump Delivery Behavior at Low Temperatures. It is self-evident that the quality of a lubricating grease can be utilized by consumers only if it is properly fed to the bearings.

During the past ten years in order to keep attention focussed on dispensing problems and also in recognition of the need for a wider understanding of the factors affecting flow properties of greases, NLGI held symposia on those subjects in 1953, 1955 and in 1957 and has included a session on spotlighting dispensing problems in this year's program.

In conclusion, the above statements should be repeated to the effect that technological advances within the lubricating grease industry have been substantial in all areas. NLGI has been alert thereto and has provided an effective forum for discussion of the pros and cons of those developments. The range of application and the level of quality of greases have been increased to a truly remarkable extent which is a positive sign that the industry is dynamic. The technical programs of NLGI have made significant contributions to that progress. ■

Wear Rates In Chassis Lubrication (Passenger Cars)

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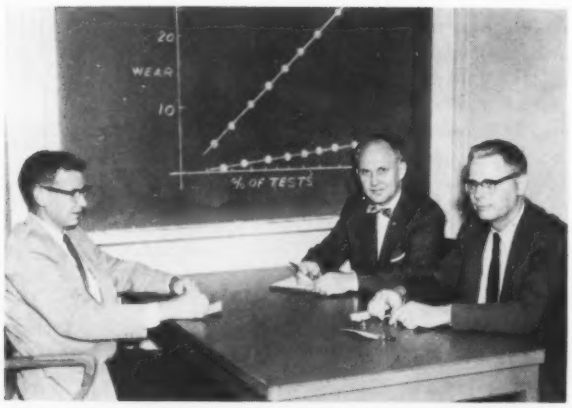

FROM the left, K. R. Bunting, who assisted in the development, with authors L. C. Brunstrum and W. L. Hayne, Jr.

Presented at the NLGI 27th annual meeting in New Orleans, October, 1959

Abstract

Although road tests have been used extensively to evaluate performance of chassis greases, little quantitative information is available on wear rates. To learn how much each chassis part wears, fifteen cars representing seven makes and lubricated with four greases were driven about 25,000 miles, and wear was determined by loss in weight of the parts.

The average wear rates of single bearings, in mg per 1,000 miles, were found to vary from 0.2 for steering parts to 4.0 for suspension bushings, the range for some of the parts being 100-fold. Apparently the major variable is the individual bearings, rather than kind of grease, make of car, or mode of driving. Precise comparisons of greases require testing each grease on several cars, and antiwear improvements would have to be marked to be worthwhile.

To avoid further difficult and costly road testing, a laboratory tester was developed that duplicates the action of plain oscillating bearings. Based on work with this tester, a grease of markedly better antiwear properties has been developed.

Introduction

From its very beginning in 1933, NLGI has been interested in automotive chassis lubrication. Articles dealing with wheel bearings, rear axles, universal joints, ball joints, and general chassis lubrication, have appeared in the Spokesman at least once a year. Although elimination of wear is a primary objective of lubrication, few of these articles concern quantitative aspects. Furthermore, wear rate often is a criterion for establishing the greasing interval for commercial vehicles and, in passenger cars, low wear rate prolongs "that new-car feel" and defers costly repairs.

Occasional articles have contributed background for road wear-rate studies that have been conducted recently. The need for field tests and inspection of disassembled parts in evaluating grease additives for load, oxidation, corrosion, water resistance, and mechanical stability was stressed (3). The motion of chassis parts has been analyzed and divided into two major groups: constant rotation, as found in wheel bearings, pumps, and pilot bearings; and oscillatory action, as found in shackles, king pins, steering linkages, universal joints, and pedal shafts (1). In the laboratory, grease performance has been studied in a journal bearing and in component parts of cars (5). One laboratory wear study on constant rotation bearings found that oil permitted more wear than grease and that graphite increased

wear (2). One road test on an oscillatory type related wear to steering effort (4).

Many questions remained unanswered. What are the actual wear rates on the several chassis bearings? How much do they vary from part to part on one vehicle, between vehicles, between kinds of driving? Can these wear rates be predicted by appropriate laboratory tests? How much can they be mitigated by additives? Answers to these questions were sought in a road test involving fifteen new 1956 cars.

WEAR RATES OF INDIVIDUAL PARTS

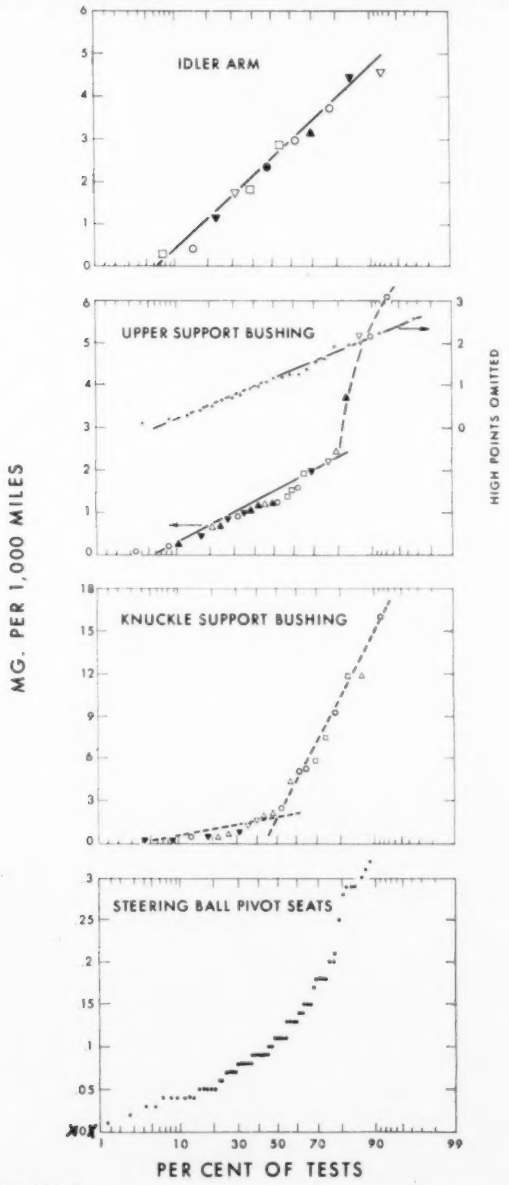

FIGURE 1.

Description of Road Test

Concurrent tests on the same cars restricted the program in several ways. Selection of the cars prevented a statistical design. For example, driving conditions were prescribed and the cars were greased at 1,600 miles rather than the preferred 1,000. However, the program adequately answered most of the questions. The major variables included seven makes of cars, two modes of driving, and four greases.

Before the test, all parts were disassembled, washed, marked, and measured, and all unsatisfactory parts were replaced. Most of the parts could be weighed to one milligram. Mating parts were weighed separately. Although numerous dimensional measurements were

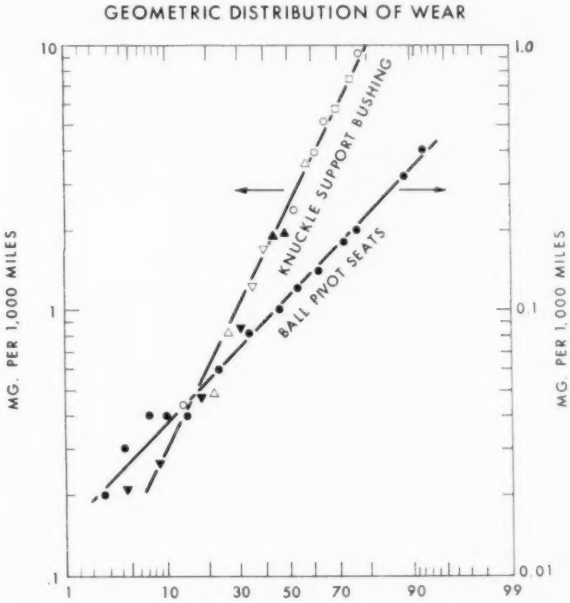

FIGURE 2.

made, weighing is to be preferred. The small changes and unsymmetrical wear patterns make dimensional measurements less exact.

Some parts are common to all of the cars. In these cases all fifteen cars were included in the average wear rates. Because of mechanical variation, wear rates on fewer cars were available for some parts. The cars that were included in the averages for the various parts are as follows:

Parts	*Make of Car*
Front wheel bearings	T U V W X Y Z
Idler arm & bushing	– – – – X Y Z
Drag link & ball seats	T U V – X Y –
Front suspension arm, shaft, bushing	T U V W – – Z
Universal joints	T U – W X Y Z

In most cases there is more than one part of a given kind per car. After the test the parts were again washed and reweighed.

Ten city cars were driven over rough streets at a maximum speed of 45 MPH under metropolitan and suburban driving conditions. Part of the time they were subjected to fast starts and stops. Two driving shifts at an average of 25 MPH permitted a total of 400 miles per day. Every other day these cars were driven slowly through a water bath one foot deep to thoroughly soak the grease-lubricated chassis parts. Because of the concurrent tests, the final mileage on these cars ranged from 17,000 to 36,000 miles.

Five country cars were driven over smooth, open roads at a cruising speed of 60 MPH. These cars covered 800 miles per day. The wheel bearings were cleaned, inspected, and repacked after 10,000 miles. The test was concluded and final inspection was made on these cars after about 20,000 miles.

All four greases were made with the same oil and had the same worked penetration. The yellow grease was an uncompounded lithium soap grease. The blue and gray greases were identical to the yellow except that the blue contained a corrosion inhibitor, and the gray contained 3 per cent of lubricant-grade molybdenum disulfide. The red grease was thickened with an organic gelling agent. Disposition of the grease on the cars was as follows:

	Make of Car						
Grease	*T*	*U*	*V*	*W*	*X*	*Y*	*Z*
Yellow	–	○	○	–	–	●	○
Blue	□	□	–	–	–	□	–
Red	▽	–	▽	–	–	▼	▼
Gray	–	–	△	△	▲	–	–
			▲				

In this table the open symbols represent city cars and the closed symbols country cars; the same code is used in the Figures.

Wear-Rate Measurements

All wear measurements were reduced to wear rate per thousand miles and plotted on probability paper. This method provides a concise statement of wear rate and any variable having a pronounced effect would be revealed by a concentration of its points at one end of the curve. Plots made for the individual elements of each bearing are of interest in determining the location and extent of wear. Plots made for car totals for bearings of a given type tend to average the variations in individual bearings and may be of more use in rating modes of driving, and greases.

TABLE I — Wear Rate of Individual Parts

Mg Per 1,000 Miles

Part	*No. of Tests*		*Range*		*Average*		*Coef. of Var.*
Front Suspension Pins and Shafts							
Upper support pin	17	(5)	0.1 - 2.5	(5.3)	1.5	(2.0)	47
Knuckle support	17	(5)	0.5 - 3.0	(9.3)	2.2	(3.0)	18
Sus. arm shaft upper	19	(3)	1.0 - 4.5	(9.8)	2.5	(3.2)	52
Sus. arm shaft lower	21	(1)	1.2 - 7.2	(15)	4.0	(4.5)	57
Front Suspension Bushings							
Sus. arm shaft upper	36	(8)	0.3 - 2.0	(30)	1.0	(2.1)	40
Upper support pin	23	(5)	0.05- 2.4	(7.2)	1.2	(1.9)	58
Sus. arm shaft lower	42	(1)	0.05- 6.4	(17)	2.0	(2.3)	..
Knuckle support	21	(1)	0.21-16	(54)	4.3	(6.5)	..
Steering Mechanisms							
Ball pivot seats	71		0.01- 0.4	....	0.20	....	..
Idler arm support	9	(1)	0.08- 0.8	(1.4)	0.44	(0.54)	68
Idler arm bushing	17		0.02- 3.3	....	0.76	....	..
Idler arm	12		0.25- 4.5	....	2.5	....	68
Universal Joints							
Bushings	72		0.05- 4.5	....	1.34	....	..
Crosser	13	(2)	0.2 - 2.0	(4.8)	0.95	(1.5)	63
Wheel Bearings							
Cones	94	(3)	0.04- 5.7	....	1.31	(1.9)	..
Cups	90	(2)	0.01- 1.3	....	0.19	(0.26)	..

WEAR tester with Hayne and Bunting collecting test data.

Wear Rates of Individual Parts

A curve was made for each part. Four types of distribution were encountered, as shown in Figure 1. Wear rate of idler arms is the single example of normal distribution. A number of parts showed this normal distribution except for a few abnormally severe wear rates. An example is the wear rate of upper support bushings. A few parts had the unusual distribution illustrated by the knuckle support bushing; about half of the points are on each of two nearly straight lines. The wear rates of the steering ball pivot seats form a smooth curve. The pattern of points on the curves for idler arms and upper support bushings is typical of all the others.

The curvature became more pronounced with increasing number of points. Wear rates for both the knuckle support bushing and the ball pivot seats are straight lines on logarithmic probability paper, as in Figure 2. The range for all parts was great; if enough items are examined, all of the curves would likely be of geometric distribution.

The data from all of the curves are summarized in Table I. For plots having normal or nearly normal distribution, the average and coefficient of variance were determined graphically. The average was determined with and without the high values, the latter being represented by the numbers in parentheses. Wear on most parts was in the range of a few mg per thousand miles. Roughly from 2 to 4 times as much wear occurred on the suspension parts as on the others. The range in wear rate for all parts was wide, as much as 100 fold in several cases. With one exception the coefficient of variance was between 40 and 68 per cent which indicates about the same precision in testing all of the parts.

Because there was no concentration of points representing any of the four greases, they must not differ markedly in wear inhibition. On the other hand, points representing country driving showed a moderate trend toward concentration at the low wear end of the curves. Apparently this service was less severe than the city driving. Because there was no concentration of the

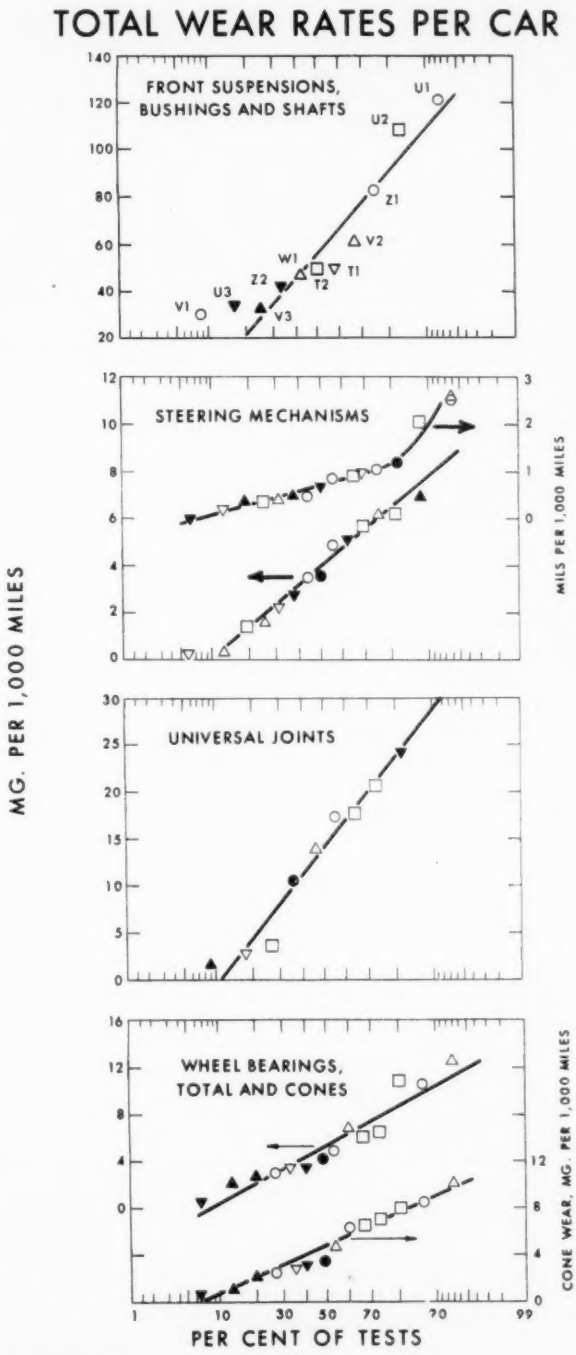

FIGURE 3.

points representing greases or cars, the wide range must have been caused by normal variations in bearings.

Composite Wear Rates

A composite wear rate for each car was calculated by adding wear rates in the following categories:

Category		Example
Plain	Oscillatory	Front Suspension
Antifriction	Oscillatory	Universal Joints
Antifriction	Rotary	Wheel Bearings

Steering parts, mostly of the first category, were handled separately, because the pattern of points was different. The composites were plotted on probability paper as shown in Figure 3. Each point represents a single grease and a single car but several complete bearings. The composites tend to smooth out the wide variations of the individual bearings. The data in each category were adequately expressed by a straight line and the following figures were determined graphically.

	Average	*Standard Deviation*	*Coefficient of Variance*
Oscillatory Plain			
Front Suspension	56	40	71
Steering Mechanism	3.9	2.0	51
Oscillatory Antifriction			
Universal Joints	14	12	86
Rotating Antifriction			
Wheel Bearings	5.2	4.0	77

Most wear occurred on the suspension parts, least in the steering mechanisms.

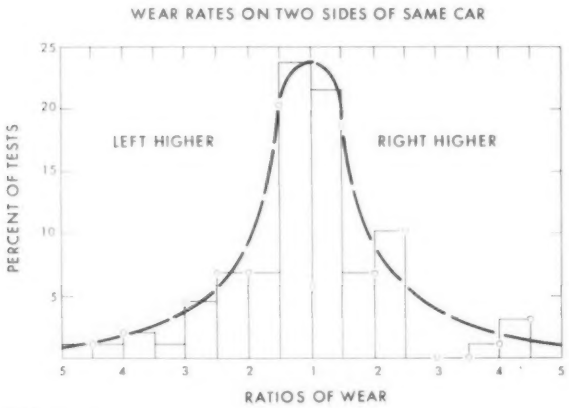

FIGURE 4.

Because the points representing the four greases are well distributed along the curves, there must be no major difference in their wear-inhibiting properties. On the other hand, the solid points of the country cars are concentrated at the lower end of several of the curves. The suspensions and wheel bearings of the cars driven in high speed service on smooth roads wore less than those at low speed on rougher streets. For the universal joints and most steering parts this trend was not found.

Right Versus Left

To reduce testing cost, two greases have at times been compared by testing them on the two sides of one car. For wear studies this practice may lead to erroneous conclusions because of the difference in individual bearings. Replotting the wear data by left and right side sheds some light on this practice. Eleven of the cars had eight similar suspension parts. Because the same grease was used on both sides, 88 comparisons could be made. The ratios of wear on the two sides were plotted against the number of tests to yield the normal probability curve in Figure 4. Ratios were considered positive when right side wear was higher and negative when left was higher.

Ratios within 1.5 to 1 were found in less than 50 per cent of the parts and ratios of 5 to 1 were found in several instances. Identical rates were found in only 5 per cent of the parts. The symmetrical nature of the curve implies the sides do not differ and agrees with an analysis made for two of the parts using only the yellow grease and city driving. For each there was a 95 per cent probability that the sides did not differ.

If the sides do not differ, we can use the two tests to compare cars. For example a comparison was made for the suspension arms on cars U and V with yellow

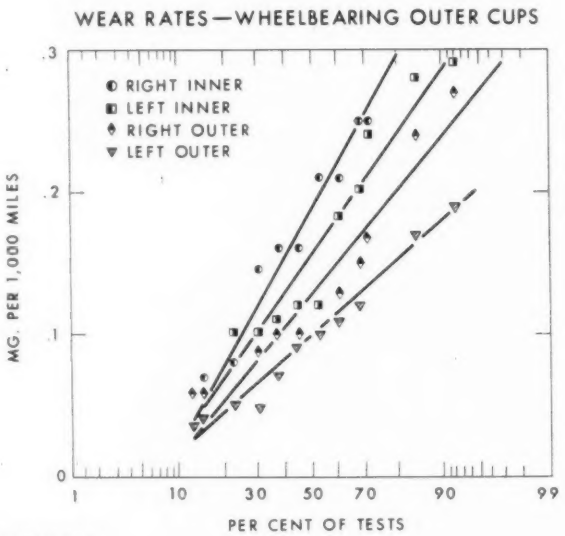

FIGURE 5.

grease and city driving. There was a 95 per cent probability that the cars did not differ.

Only the wheel bearings showed a difference in wear on the two sides. Although there was much less wear on the four outer cups, they are a sensitive indication of wear. In Figure 5, wear rate in the four locations are plotted separately and without regard for car or grease. On both sides of the car, more wear occurred on the larger of the two cups. Higher wear rates were found on the right side than on the left. The latter comparison has better than 95 per cent probability.

Comparing Greases

With the exception of the red grease, each grease was used in two or three city cars. If we ignore the possibly small difference in wear rate on the cars, the averages

per car in the three service categories are:

	Wheel Bearings	*Front Suspensions*	*Universal Joints*
Red	3.3	49.1	16.3
Yellow	6.2	77.7	17.2
Blue	8.3	78.5	13.9
Gray	9.7	53.6	13.6

At the 90 per cent confidence level, the yellow and blue grease probably did not differ in wheel bearings, yellow and gray did. In front suspensions, yellow, blue and gray probably did not differ. Similarly, in the universal joints these three greases did not differ. Thus definitive product comparisons require tests of each grease on three or four cars of the same make.

The knowledge that such gross differences in wear rate appear in service has profound significance in developing greases. Test programs must either be extensive or made on selected bearings, and minor improvements in wear inhibition will not be noted nor have practical significance. On the other hand, the high wear

FIGURE 6—The oscillating plain bearing wear tester used.

found in some parts makes the attempt attractive. To avoid costly road tests, a good laboratory wear test is a prerequisite.

Laboratory Wear Tests

Groups such as CRC, ABEC, and ASTM have developed tests in antifriction bearings in both constant rotation and oscillatory service. But for greases in plain oscillatory bearings no test is generally accepted. What is needed is a rapid test that can be completed in one day, yet it should not be accelerated by increasing ambient temperature or application of exceptional loads. It should accommodate small test pieces and allow close control of such factors as bearing conformity, finish, and hardness. Such a tester has been built and used.

The oscillating plain bearing wear tester duplicates the loading and action of some chassis suspension parts and steering components. Figure 6 shows how a unit

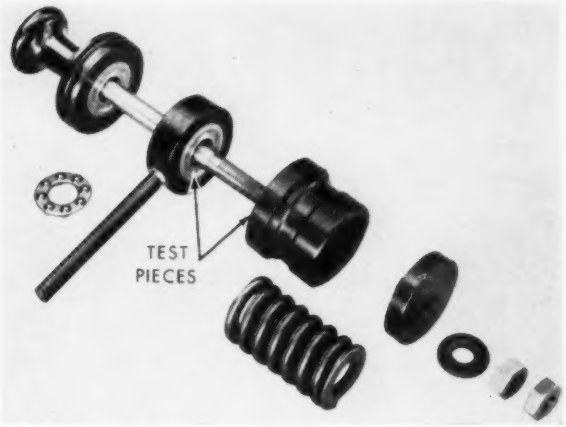

FIGURE 7—Breakdown of the bearing assembly employed.

containing a plain thrust bearing slips into a holder, and is oscillated through 12 degrees 1,800 times per minute by an electric motor. Because the device comes to rest at both ends of every oscillation, it operates at high friction, as do chassis parts. Unlike in the externally similar fretting tester, the total bearing surfaces are in continuous contact. Wear is determined by weight loss of the bearing.

Orientation of the test bearing is shown in Figure 7. It consists of the two flat parts of a ball thrust bearing with the test grease occupying the normal location of the ball and retainer unit. One of the test pieces is annealed to 42 Rockwell hardness; the other is 62 as furnished.

A test is conducted by first polishing the two pieces with 400 grit paper to assure a flat surface with a uniform finish. The pieces are then washed in solvent, weighed, lubricated thoroughly with the test grease, and placed in the spring-loaded housing. A spring load of 100 pounds is applied before the screws which lock

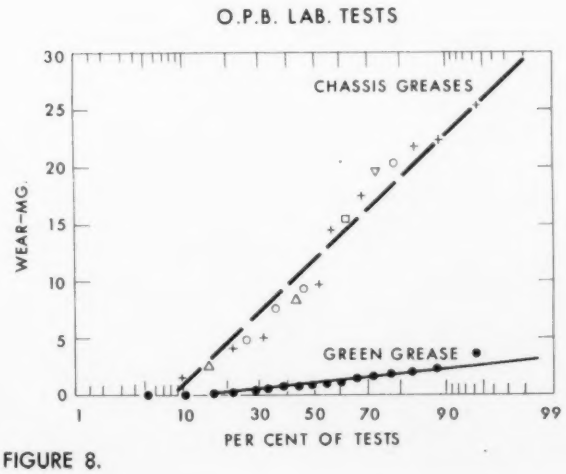

FIGURE 8.

the pieces into place are tightened. This procedure insures proper contact of the surfaces. After operating the apparatus by hand for a few cycles at this load, a load of 500 pounds (approximately 910 psi on the projected area of the test-piece surfaces) is applied, the housing is mounted on the stand, and operation is continued for a 20-hour period.

At the conclusion of the test, the rig is disassembled and the surfaces of the pieces are examined to observe if the grease film is intact and if any changes in the grease are apparent. The pieces are then cleaned and weighed.

Tests have been run on the color-coded greases, several conventional greases, and on a special wear-inhibited grease. Repetitive testing of the yellow, blue, gray or red grease is shown on the upper line in Figure 8. On such samples the test has poor repeatability probably because wear is a self-catalytic phenomenon, eroded wear particles causing more wear. Each cross represents one test on other conventional chassis greases. The range is 2 to 25 milligrams. No grease gave consistently low wear.

As shown on the bottom line, a special lithium grease, colored green, was tested many times. The average wear is 1.0 milligram and the standard deviation 0.9, which show that the green grease consistently yields low wear.

Conclusion

Something about the range of wear rates on all lubricated parts is now known. They are generally lowest in steering mechanisms and highest on suspension parts. Statistical differences appear in makes of cars, modes of driving and in the grease used. But variations among duplicate parts seem to be large enough to overshadow these differences. Therefore tests on a single car are often misleading and tests on three or four cars are required to evaluate a single variable.

The direction that future wear studies on grease should take is fairly clear. Laboratory testers for measuring the protection afforded by grease are now available for oscillatory as well as rotary motion; the next step should be standardization of a test procedure for an oscillatory tester as is already being done for rotary types. To prove the performance of a new grease, carefully designed road tests involving many cars are necessary. The expense will likely be prohibitive except when laboratory testers indicate that markedly superior performance can be expected.

Even the highest wear rates observed may be acceptable today in practice. But the challenge of achieving lower rates more of the time is nonetheless inviting. Neither present bearings nor present greases have approached the ultimate development. The answer to future chassis-lubrication demands lies in combinations of better bearings and better greases.

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Acknowledgements

K. R. Bunting assisted in the development and operation of the tester, and the field tests were run by Southwest Research Institute. ■

About the Authors

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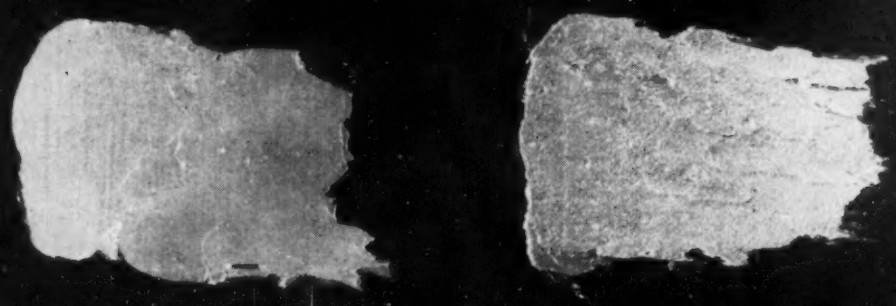
W. L. Hayne, Jr. *received a BS and an MS in chemical engineering in* 1947, *from the University of Louisville, after interrupting his work to serve as a submarine officer in the Navy from* 1943 *to* 1946. *Mr. Hayne joined the research department of Standard in* 1948. *He is a member of Sigma Tau, Theta Chi Delta, AIChE and ASLE. He has been a previous* NLGI Spokesman *contributor, in* 1953, 1955, 1957 *and* 1959.

Sensory Examination of Lubricating Greases

By: Albert S. Orr—Gulf Oil Corporation



Polished steel plate—sample with soap particles at right.

Reprinted from the August, 1958 NLGI Spokesman

CUSTOMERS OFTEN JUDGE lubricating greases, at least in a preliminary way, by what they can see, feel, smell and possibly taste when a package is opened. This first impression of the grease, like first impressions of people, is often difficult to dispel and may adversely influence the customers' opinion despite excellent performance in actual service.

When the cover is removed from a pail or drum of grease, the customer looks at the surface of the grease and forms a general opinion as to the color and overall appearance of the grease. He will note any free oil on the surface of the grease or in depressions. He may use a spatula or putty knife to spread a thin film of grease on some smooth surface and observe whether it contains soap particles or visible foreign matter. If a grease is not similar in color and general appearance to earlier receipts of the same product, it is immediately suspect and may be refused.

Almost universally the grease user will place a small portion of the grease between the thumb and forefinger and pull it apart and push it together a few times. From this he can note the texture of the grease and may form an opinion as to whether it is too hard or too soft for his use. The thumb and forefinger test will show the texture of a lubricating grease as well as any formal laboratory test now available, but this test should not be used as a substitute for the penetration test for determining the consistency of a grease.

The grease user cannot avoid smelling a grease when he opens a pail or drum and will, of course, complain of any unusual or objectionable odor. Perfumes or maskants were once widely used to cover up unpleasant odors in greases, but this practice has almost disappeared.

In the past, many grease makers and some customers would taste a grease to determine whether it was alkaline or acidic. This is not recommended as more precise laboratory methods are available for determining

acidity, and some of the components of modern greases may be harmful when placed in the mouth. Although lubricating greases do not usually contain highly toxic materials, they are not to be eaten.

The results of sensory examinations of greases have at times been described in rather picturesque terms. These terms may vary widely among different persons, thus leading to misunderstandings.

The purpose of this paper is to propose a standard vocabulary of terms for describing the sensory observations of a lubricating grease. Some of the methods and equipment used by one grease maker to assure shipment of greases having uniformity of color, appearance, texture and odor are presented as the background for this discussion.

Color

There is no readily available or generally accepted method for determining colors of lubricating greases and expressing colors by numerical values as is done with lubricating oils. Thus, the grease manufacturer and user must use words in describing the color of the product. Lubricating greases can be made in almost any shade and intensity of color through use of dyes, fillers, non-soap thickeners and other additives. However, the color of most conventional soap-thickened greases is controlled by the color of the lubricating oil base and the metallic soap. Such greases may be opaque or clear, depending on the type of soap and other variables in composition and processing. The color of opaque greases may best be described as some shade of brown. For clear grease, some shade of amber seems more suitable. It is suggested that the shade or intensity be characterized as very light, light, medium, dark and very dark. The very light shade would represent only a faint brown for an opaque grease and a faint amber (yellow) for a clear grease. The very dark shade would apply to a grease that is almost black.

In many greases, the bloom or fluorescence of the mineral oil component is visible and may affect the apparent color. If so, this should be noted in describing the color. For instance, a grease containing Pennsylvania cylinder stock may have a pronounced green bloom. The color of such a grease might be described as dark brown–green bloom. On the other hand, a grease made from a naphthenic oil might have a discernible blue bloom, and its color could be described as light amber–blue bloom. If no bloom is readily apparent, no mention is made of bloom in describing the color.

It is important that all greases be examined for color and bloom by reflected light, preferably daylight, and in metal containers–sample cans, pails or drums. The color of greases in glass sample jars may, at times, be misleading, particularly when observed through the glass. This may be due to reflection from the glass or to transmission of light through the grease. In most cases, the customer observes the color of grease in a metal container.

Greases containing fillers, dyes and some of the new non-soap thickeners may have colors matching almost any hue of the rainbow. At extremes a grease containing a substantial amount of graphite is black, while a grease containing zinc oxide may be almost white. Dyes of almost any color may be used. Sometimes this is done to give the grease a distinctive color for ready identification. On the other hand, some of the newer thickeners are actually colored pigments or dyes which will impart a characteristic color to the grease. In many cases where fillers, dyes and colored thickeners are used, the color of the oil base will modify to some extent the color imparted by the filler, dye or thickener. When grease colors cannot adequately be characterized in terms of brown or amber as suggested above, the color should be described in terms of the predominant color with adjectives to indicate shade and intensity, and also, any less predominant color that is visible. For example, a grease dyed dark red may have

FIGURE 1, texture—buttery

FIGURE 2, texture—short fiber

FIGURE 3, texture—long fiber

FIGURE 4, texture—stringy

a brownish tinge due to the color of the oil base and soap, and should thus be described as a dark brownish red grease.

The grease maker's main problem with regard to color is to assure that all shipments of a given grease have a uniform color. One grease maker handles this by preparing a set of color standards by selecting samples from the lightest and darkest colored batches of each grade that are considered acceptable. These samples are put up in small cans and retained in the laboratory for comparison with each production lot of that particular grease. A sample of the production lot is placed in an identical sample can and compared with the light and dark standards for this particular grease in daylight or under a daylight lamp. To be acceptable for shipment, the production lot must be no lighter in color that the light standard and no darker that the dark standard. Usually, the color of a production lot will fall between that of the two standards. Since some greases may change color on aging, the standard samples are replaced at about yearly intervals by again selecting typical production lots for standards.

Appearance

When a customer removes the cover from a package of grease and looks at it, he may make a number of other observations in addition to the color of the grease. He probably will note whether the surface of the grease is smooth or rough, whether there are cracks in the surface and whether separated oil is present. He may also note whether the grease has a bright or dull luster. If a thin film of the grease is spread on a smooth surface using a spatula or other suitable tool, he may observe whether the grease is grainy or smooth and whether it contains visible soap lumps or foreign matter. It is proposed that the word "appearance" with regard to grease include all of the visual observations that might be made on examining the surface of a grease in the final package and on examining a thin film spread on a smooth surface. Thus, it would include all of the items shown in Table I.

One grease maker uses a somewhat more elaborate thin film examination than is normally employed by customers. The main purpose of this is to detect soap particles and foreign matter that might appear in the finished grease due to failure of the screen in the filling line. An illuminated inspection plate as shown on cover illustration is used. This consists of a triangular piece of opal glass illuminated from below by a single daylight fluorescent tube which is enclosed in a box on which the glass plate rests. A sample of the grease to be examined is spread on the glass plate with a spatula to give a thin uniform film. With the light on, soap particles and foreign matter can be readily detected, and if found, will be cause for rejection of a batch of grease. Generally, at least three samples are taken during filling out of a kettle of grease. These will be from the first, middle and last packages, and all must be free from visible soap and foreign matter and uniform with respect to color and graininess for the entire batch to be shipped.

For certain greases, particularly semi-fluid oils, transparent soap lumps are more readily detected if the grease is examined by reflected light. In these cases, the sample is spread in a thin film on a polished stainless steel plate for examination under a daylight lamp. A given grease may be examined both by transmitted light as described above and by reflected light on the steel plate. Discernible soap particles or foreign matter by either procedure is cause for rejection or further processing.

These tests are not used as a substitute for the ASTM method of Test for Deleterious Particles in Lubricating Grease, ASTM D 1404-56T, which will detect some particles not readily visible and allows a semi-quantitative estimate of the number of particles which might prove at least slightly abrasive in service.

Texture

When a customer examines a container of grease, he will almost subconsciously place a small portion of the grease between his thumb and forefinger and press together and pull apart a few times. From this simple procedure, the customer gets an idea of the texture of the grease. The following terms are recommended for describing texture:

Buttery—separates in short peaks with no discernible fibers.

Short Fiber—short "break-off" with evidence of fibers when portions are separated.

Long Fiber—has a tendency to stretch out into a long single fiber when portions are separated.

Stringy—has a tendency to stretch or string out with no evidence of fiber structure when portions are separated.

Resilient—capable of withstanding compression between thumb and forefinger without permanent deformation or rupture.

Brittle—has a tendency to rupture or crumble when compressed between thumb and forefinger.

Many other terms have been used to describe grease texture. Among these are smooth, grainy, feathery, ropey, crumbly, rubbery, tacky, etc. As noted above, we would like to reserve "smooth" and "grainy" for use in describing the visual appearance of a grease when examined in a thin film. It is believed that the six terms proposed above will satisfactorily describe the texture of any grease that may be encountered and for the sake of uniformity, we would suggest their exclusive use instead of variations such as feathery, ropey, crumbly, rubbery, tacky, etc.

Odor

Lubricating greases may vary widely in intensity and type of the odor that is encountered on opening a package. Most freshly prepared, high quality, conventional soap thickened greases will have little or no odor. Some greases tend to become rancid on aging while others contain additives or other ingredients that impart typical odors. Some odors may be pleasant while others may be disagreeable, though this is to some extent, a matter of individual preference and depends partly on the intensity of the odor and partly on the type.

In describing the odor of a grease, an attempt should be made to indicate both its intensity and its type. The following intensity scale is suggested:

None—no odor detectable.

Slight—odor would not be detected by the average customer but would be detected by an experienced observer.

Mild—odor might be detected by average customer but only if his attention were called to it.

Noticeable—odor readily detected by customer.

Strong—odor that would force itself on attention of customer and possibly render the grease unsuitable for use in confined areas.

The types of odor that may be encountered will vary widely and in general are related to the ingredients used in making the grease. Most commonly, there will be the rather mild odor associated with petroleum lubricating oils. This may be more intense with less highly refined oils and lower viscosity oils. A pronounced kerosene or gasoline odor may indicate contamination and should be noted and investigated. The fat from which the soap is made may impart some odor to the grease, though generally, this is mild if high quality fats are used. Some fats and the soaps made from them may become rancid on aging, and develop a characteristic acidic odor. Many of the additives used in greases have characteristic odors. Some anti-oxidants may have a phenolic or medicinal odor. Some extreme pressure additives may have a sulfury odor similar to hydrogen sulfide or sulfur dioxide. Lead naphthenates usually have a characteristic naphthenic acid odor.

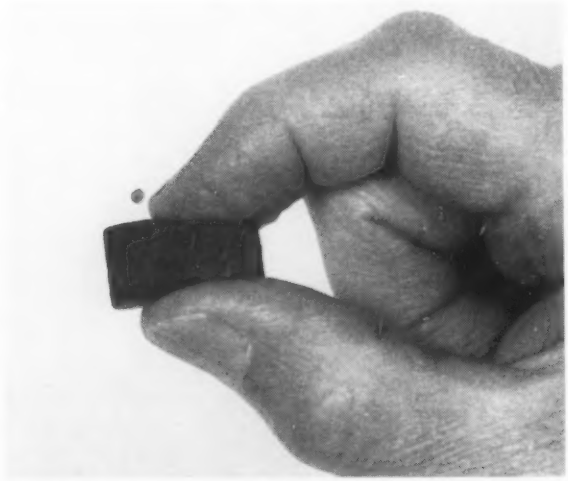


FIGURE 5, texture—resilient

FIGURE 6, texture—brittle

Often, an experienced observer can identify the odor as resulting from, or being similar to, a specific compound such as nitrobenzene, oil of wintergreen or other scenting agent. Some of the greases containing non-soap thickeners have characteristic odors due to the modifying agent used. For instance, some bentone greases have a noticeable odor of acetone or methyl alcohol.

The type of odor should be described in accordance with the following table amplified if possible by reference to a specific chemical compound or product:

Type of Odor	*Examples*
Petroleum	Lubricating oil, kerosene, gasoline
Fatty	Well refined fats, vegetable oils and fatty acids
Flowery	Violet, geranium, and many others
Spicy	Cinnamon, cloves, etc.
Medicinal	Phenol, iodoform, etc.
Rancid	Rancid butter, lower fatty acids
Ammoniacal	Ammonia, alkyl amines
Sulfury	Hydrogen sulfide, mercaptans, sulfurized fats
Burnt	Burnt wood or straw
Acrid	Scorched fat
Grassy	Crushed grass
Musty	Decomposed straw
Decayed	Spoiled meat
Septic	Stale sewage

Some odors of lubricating greases are transitory and disappear or diminish in intensity in a short time after the package is opened. It is suggested that odors be observed immediately after opening the package and then again an hour or two after opening. If there is any difference in type or intensity in the two observations, this should be reported.

Some odors tend to dull the olfactory sense and cannot be detected and identified if too intense. It is recommended that the first sniff of any grease be taken very cautiously immediately after removing the cover from the package by fanning air from the top of the package toward the face.

Of course, in order to properly evaluate the odor of a grease, it is desirable to conduct the examination in an area that is free from other odors.

As noted above, both the intensity and type of odor should be reported using the terms suggested above amplified by reference to specific chemical compounds where these can be identified by the observer.

TABLE I

Proposed Standard Terms for Reporting Visual Examination of Lubricating Greases

APPEARANCE

1. Color
   a. Amber—very light, light, medium, dark, very dark
   b. Brown—very light, light, medium, dark, very dark
   c. Other—specify shade and intensity of predominant color that is visible.
2. Bloom or Fluorescence
   a. Green—note intensity—slight, medium, marked
   b. Blue—note intensity—slight, medium, marked
   c. None
3. Luster
   a. Bright
   b. Dull
4. Surface Examination in Package
   a. Smooth
   b. Slightly rough
   c. Rough
   d. Cracks—note number and size
   e. Separated oil—note approximate quantity
5. Thin Film Examination
   a. Smooth
   b. Slightly rough
   c. Rough
   d. Grainy
   e. Soap particles
   f. Foreign matter

Conclusion

The foregoing discussion outlines the conditions for making sensory observations of lubricating greases as accurate and meaningful as possible. The limitations of such observations are also mentioned.

A vocabulary for describing the results of observations made by sight, touch and smell has been proposed. It is believed that the general use of this vocabulary will eliminate many misunderstandings between customer and grease supplier. ■

About the Author

ALBERT S. ORR, *a native of Texas, obtained his B.S. degree in Chemical engineering from Texas A&M college in* 1924. *Immediately after graduation, he started work for the Gulf Oil corporation in their Port Arthur, Texas laboratory. In* 1930 *he was transferred to Gulf's refinery technology laboratory in Philadelphia, Pa., and became director of that laboratory in* 1950. *In* 1951 *he was transferred to Gulf's main office in Pittsburgh, Pa., and is currently working in the coordinator's group of the manufacturing department handling matters pertaining to product development and product quality. Much of this work has to do with grease development and quality. Mr. Orr is a member of the American Chemical Society, Society of Automotive Engineers, American Society for Testing Materials, and other technical societies.*

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Literature and Patent Abstracts

Composition

Lubricating Greases Having Extreme Pressure Qualities

According to Peck (U. S. Patent 2,895,912, assigned to Gulf Oil corporation) addition of two to ten per cent of a mixture of sublimed blue lead and sulfurized sperm oil to lubricating greases gives sufficient E. P. qualities to stand up to a 90 pound Timken Test Machine load. For highest E. P. results the ratio of the two ingredients should fall within the range of 1 to 3 or 1 to 5, that is one part of blue lead to three or four of sulfurized sperm oil.

Sublimed blue lead is essentially a basic sulfate but does contain some lead oxide and minor amounts of lead sulfide, lead carbonate, zinc oxide and also carbon which gives it the blue cast.

While it is stated that the additives benefit either calcium or lithium base lubricating greases the latter types make up most of the illustrations. For example, a Stratford contactor was charged with 28.8 parts of Texas oil of a viscosity of 500 SUS at 100°F., 8.24 parts of hydrogenated castor oil, 0.93 part of prime tallow, 1.25 parts of lithium hydroxide monohydrate and 0.28 part of water. The mixture was heated to 400 to 410°F. while the pressure increased to 100 psi. At the above pressure, the vessel was vented to atmospheric pressure before reaching maximum temperature. After dehydrating the soap base, 11.3 parts of the above oil was added after which the mass was transferred to an open kettle. Here 4.18 parts of the 500 oil and 40.87 parts of Mid-Continent Bright Stock having a viscosity of 150 SUS at 210°F. were added over a period of three to four hours while the lubricating grease cooled to 230 to 240°F.

At this point a mixture of 0.9 part of sublimed blue lead and 4.05 parts of sulfurized sperm oil was added.

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Free Fatty Acid (as Oleic)	10.0-14.0%	Saybolt Viscosity at 210°F.	155 sec. approx.
Moisture	0.5-1.2%	Iodine Value (Hanus)	20.0-35.0
Ash	0.1% Max.	Saponification Number	100.0-116.0
Melting Point	36.0°-44.0°C.	Penetration at 77°F. unworked	150-180 mm/10
Flash Point	540°F. approx.	worked	340-370 mm/10
		Color ASTM (Max.): 10%	4.5
		30%	Greater than #8

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Since adjustment of consistency was required, 4.92 more parts of 500 oil and 4.53 further parts of Bright Stock were added to provide a No. 2 NLGI consistency. Also in order to keep the percentages of sublimed blue lead and sulfurized sperm oil in the final product at 1.0 and 4.5 respectively, 0.1 part of the former and 0.45 part of the latter were added.

The finished product had the following composition in weight per cents:

500 at 100 Texas oil	43.50
150 Bright Stock	41.10
Lithium soap of hydrogenated castor	8.10
Lithium soap of tallow	0.90
Glycerine	0.90
Sublimed blue lead	1.00
Sulfurized sperm oil	4.50

To show how the ratio of the two E. P. additives influences the Timken values a number of combinations were tested. Five per cent of the blue lead alone stood a Timken load of 30 pounds. The same of sulfurized sperm alone stood a 14 pound load. Approximately one to one ratio with a total of the two additives withstood a 20 pound load. A lubricant containing one per cent of blue lead and four per cent of sulfurized sperm oil gave a Timken result of 70 pounds. Changing this to 0.8 and 4.1 per cent respectively resulted in a 90 pound Timken load without failure.

High Temperature Water Resistant Lubricating Greases

According to MacKenzie (U. S. Patent 2,898,295, assigned to Godfrey L. Cabot, Inc.) lubricating greases thickened by means of finely-divided inorganic materials are rendered water-resistant, even at high temperatures, by the addition of five to forty per cent by weight of the thickening agent of a polyamine.

Not all polyamines are effective for the above purpose but suitable ones can be prepared by reacting a medium or high molecular hydro-

carbyl substituted primary or secondary amine with acrylonitrile and then catalytically hydrogenating the resulting amino nitrile. Duomeens available from Armour Chemical division are satisfactory for the water repellent additives.

Thus, five parts of N-(tallow hydrocarbyl) propylene-1, 3 diamine and 52 parts of pyrogenic silica (Cabosil) were milled into 750 parts of paraffin base lubricating oil having a viscosity at 210°F. of 148 SUS and a V. I. of 102. Using a 3-roll paint mill, a lubricating grease having a worked penetration of 298 was obtained. On being refluxed with boiling water, uncompressed lumps of this lubricant were still intact and substantially unchanged in consistency after 50 hours and still of useful consistency after over 100 hours.

Complex Soap-Salt Thickened Lubricating Greases

Mixtures of acids of varying molecular weight if used in optimum percentages and combined with either calcium or a mixture of calcium and barium form thickeners for lubricating oils which contribute to extreme pressure characteristics, oxidation stability and long bearing performance life. Such products are described by Schott (U. S. Patent 2,898,297, assigned to Socony Mobil Oil Co., Inc.). While a broad range is claimed for each type of acid named, the optimum percentage by weight is as follows: low molecular weight, that is acids having one to six carbon atoms, 28; intermediate molecular weight, that is acids having seven to twelve carbon atoms, 17; high molecular weight, that is acids having thirteen to twenty-two or more carbon atoms 14; and coconut oil acids 41.

A typical lot of such a lubricating grease was made in a Stratco contactor which was preheated to 250°F. and then charged in the order indicated below: solvent refined naphthenic oil of 60 V. I. and 500 SUS at 100°F., 56 pounds; hydrated lime 9 pounds 7 ounces; acetic acid 8 pounds 5 ounces; water 4 pounds; caprylic acid 5 pounds; coconut oil 12 pounds 11 ounces; hydrogenated tallow fatty acids 4 pounds 3 ounces; and litharge 3 pounds. The agitator of the contactor was in motion during the addition of all of the ingredients. In about one hour the mass reached a temperature of 345°F. while the pressure in the contactor registered about 100 psi. The contents was then blown into a preheated open steam jacketed kettle and when a sample indicated 0.5 to 0.7 per cent calcium oxide the mass was dehydrated. The charge was then heated and paddled for 1½ hours at 300 to 320°F. after which 44 pounds more of the 500 oil and 30 pounds of a naphthenic bright stock having a viscosity of 130 to 140 SUS at 210°F. and a negative V. I. were added.

Heating of the open kettle was then discontinued and the mass was recycled through a high pressure homogenizer until the temperature dropped to 180°F. When the temperature was about 190°F., 5 pounds 3 ounces of Alpha-Chlor 33 were added. Finally the worked penetration was adjusted to 290 to 300.

This product was OK on a Timken load of 45 pounds. With no oxidation inhibitor added the pressure drop in an oxygen bomb was 10 pounds in 200 hours. The dropping point was above 500°F. In a loaded Navy tester the uninhibited lubricating grease ran 1500 hours and after the addition of 0.5 per cent of Ionol ran 3500 hours.

High Temperature Lubricating Greases

Lubricating fluids thickened with the reaction product of arylene isocyanates and organic-substituted oxygen-containing acids of phosphorus having free hydroxy groups form lubricating greases with high dropping points and good water resistance.

In general, these products are prepared in situ by dispersing the diisocyanate and the alkyl-substituted phosphorus-containing acid

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in a portion of the lubricating oil and heating until the reaction is complete. This will be at 150 to 400°F. for one-quarter to twenty-four hours.

According to Norton and Baker (U. S. Patent 2,898,300, assigned to Esso Research and Engineering Co.), a lubricating grease was prepared by dispersing 20 grams of bitolylene diisocyanate and 30 grams of di(2-ethylhexyl) hydrogen phosphite in 50 grams of Dow Corning 550 silicone fluid, followed by heating to 300°F. for one hour. After cooling to room temperature the lubricant had a worked penetration of 360 and a dropping point above 500°F.

Process

Forming a Lubricating Grease Containing Metal Salts of Mono And Dicarboxylic Acids

Pattenden, Sproule and Norton in U. S. Patent 2,898,296, assigned to Esso Research and Engineering Co., describe a procedure whereby salts of dicarboxylic acids can be readily dispersed in lubricating oil. If a mixture of fatty acid, such as stearic, and a dicarboxylic acid, such as sebacic, are reacted with an alkali in the presence of oil it is found that the metal salt of the dicarboxylic acid does not readily disperse.

However, if in place of the sebacic acid an amount of diester containing the required proportion of the sebacic acid is used the salt formed will remain dispersed as a part of the thickener. For example, a lubricating grease was prepared by mixing 10 grams of stearic acid and 10 grams of di-2-ethyl hexyl sebacate (equivalent to 4.8 grams of sebacic acid) with 80 grams of a lubricating oil having a viscosity of 300 SUS at 100°F. and a 70 V. I. Next 3.6 grams of lithium hydroxide were added and the mixture was heated to 400°F. for 15 minutes. The 2-ethylhexanol which formed during the reaction was driven off almost as rapidly as it formed.

Upon cooling the resulting lubricating grease had a worked penetration of 265 and a dropping point of 500°F. A similar combination and procedure permitted the manufacture of a lubricating grease in which the fluid was a silicone.

Process for Manufacture of Lithium Base Lubricating Grease

Zweifel, Voss and Gower (U. S. Patent 2,898,298, assigned one-half to Sinclair Refining Co. and one-half to Richfield Oil corporation) describe a process for the manufacture of lithium base lubricating grease in which at least 80 per cent of the soap is derived from hydrogenated castor oil.

The process consists of four steps, namely saponification of the fatty material with lithium hydroxide in the presence of a portion of the total oil, dehydrating the mixture at a maximum temperature of about

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330°F., adding any additional oil required, and finally colloidally milling the unhomogenized mass to decrease the penetration by 25 to 125 points. With this method of manufacture the thickener is present in the form of fibers about 1 micron length. Lubricating greases so formed show unusual resistance to breakdown in field service.

A typical lithium base lubricating grease was made by charging 49.5 parts of beef tallow, 449.5 parts of hydrogenated castor oil and 1580 parts of an oil having a viscosity of 81 SUS at 210°F. to a steam jacketed grease kettle and mixing at 180 to 190°F. In a separate kettle 76.5 parts of lithium hydroxide were dissolved in 1344 parts of boiling water after which this solution was added to the fat-oil mixture in the first kettle. After mixing the mass for fifteen minutes at 180 to 190°F. heat was applied and finally the mixture was dehydrated at 300 to 320°F. Steam was then shut off and 2012 parts of oil added while stirring. When the lubricant reached a temperature of about 200°F. 10 parts each of hyamine B and octylated arylalkylated diphenyl amine were added. After cooling to 170°F. the lubricating grease was processed through a colloid mill set at 0.010 inch clearance at a rate of 150 pounds per minute, deaerated and packaged.

This finished lubricating grease, which contained 12.15 per cent soap and 0.03 per cent free alkali, tested as follows:

Worked penetrations–	
60 strokes	276
10,000 strokes	283
100,000 strokes	297
Dropping point °F.	379
Wheel bearing tests	
At 40 m.p.h., 220 F.	Pass
At 60 m.p.h., 250 F.	Pass
Oil separation (ANG-10 test)	1.5
Copper corrosion 24 hrs. 210°F.	No stain
Boiling water test 15 min.	No turbidity

Electron micrographs of the soap fibers in the above lubricating grease are compared with similar views of the soap fibers in a product made at higher temperatures. The latter are up five microns in length compared with one micron in the product made at the lower temperature.

Testing

The Gear Rig as an Oil Tester

Earle A. Ryder, *Lubrication Engineering*, 15 No. 8, August 1959, p. 319-324.

According to Ryder "A 'gear rig' is a machine for testing gears or gear lubricants, generally smaller in scale than the device for which it substitutes, but sometimes consisting of parts of the main device. The feature of the gear rig is that gears are used as test specimens."

The types of failure which can be determined with such apparatus are scuffing, pitting and fatigue. It can also be used for rating gear oils. In spite of the fact that Ryder does not consider repeatibility too good, such rigs do correlate with full scale experience and also do rate oils correctly.

Both Borsoff and Ku, who have written comments on Ryder's paper, consider reproducibility somewhat more exact than does Ryder.

Gear Lubrication

Recent Developments in the Lubrication Of Heavy Duty Industrial Gearing

G. P. Maurer, *Lubrication Engineering* 15 No. 9, 360-366, 371, (1959). Results of tests of various gear lubricants are given when used on a large gear set operating at 15 rpm for the large gear. This was a herringbone gear with 8⅜ inch face width of each helix. Film breakdown was determined by periodic stops to check the point at which no apparent film could be wiped from the flanks of the teeth with a finger.

almost everything that moves either in actual operation or in the process of its making . . . from gate hinges to tractor wheels . . . depends upon grease. That is why lubricants should be bought with care. You can always depend upon Deep Rock highest quality greases and lubricants. They are manufactured to give **top lubrication to all moving parts.**

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- Resistance to welding of metals at high temperatures
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A series of residual base lubricants containing EP additives were diluted and applied by spraying. In undiluted form these varied in viscosity from 2100 to 9000 SUS at 210 F. No increase in film endurance for viscosities higher than 3000 SUS at 210 F was found. Next a series of lead naphthenate lubricants (percentage of lead not given) varying in viscosity from 130 to 950 SUS at 210 F were tested. At a viscosity of 430 SUS at 210 F the film endurance of such a lubricant is equal or better than that of a residual compound having a viscosity of 3000 SUS at 210 F. With a viscosity above 900 a 4 ounce application of a lead naphthenate base lubricant had a life of over 10 hours. Lubricating greases (types not given) with penetrations of 295 to 355 were tested. Only those with penetrations above 315 could be sprayed and the maximum endurance of films obtained with these products was 3¾ hours.

From the results of these tests recommended viscosities for both intermittent and continuous applications at different ambient temperatures is tabulated. Also recommended quantities for application at various periods is tabulated.

Industry News

New Testing Machine

A new lubricant testing machine designed for environmental research has been announced by the Alpha-Molykote corporation.

The machine, known as the Model LFW-3, can be adapted to testing either dry or liquid lubricants, at ambient to high temperatures, with oscillatory or rotational motion, over a wide range of velocities and loads. A high temperature furnace is supplied as standard equipment. However, sufficient space has been provided in the specimen area for the future installation of a variety of environmental chambers such as one for low temperature testing. A five H. P. motor allows the machine to operate at friction coefficients of .5 at full load.

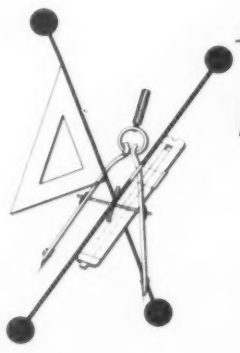
The Model LFW-3 is furnished complete and ready to operate with all electrical equipment necessary to give full protection against overload and low voltage. Instrumentation is mounted in a separate cabinet wired for easy connection to or disconnection from the testing machine.

For detailed specifications of the Alpha Model LFW-3 lubricant testing machine, write the Alpha-Molykote corporation, 65 Harvard Avenue, Stamford, Conn.

Sonneborn Receives Miley Process Patent

A patent on the Miley process for the utilization of refinery acid sludge has now been granted to the inventor of the process, G. Hunter Miley. The patent has been assigned to L. Sonneborn Sons, Inc.

The process, developed by Mr. Miley in 1955 at Sonneborn's refinery at Petrolia, Pa., converts the previously useless acid sludge into valuable products. This contrasts sharply with previous methods, which were designed mainly to dispose of the sludge.



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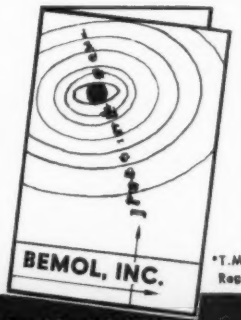

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- YOUNGSTOWN — Bemol, Incorporated, 125 West Commerce St., Youngstown 3, Ohio
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The heart of the Miley process is a unique retort into which the sludge—resulting from treatment of petroleum products with sulfuric acid—is fed. The retort produces sulfur dioxide and coke as its main products, along with a variable quantity of gaseous hydrocarbons. These gases are profitably used as part of the fuel required by the retort, so that they are consumed in the process.

Operation of the retort is largely automatic, and one man can supervise the running of up to three, since his primary duties consist of recording temperatures, adjusting sludge feed, and general supervision.

The process and retort are covered by U. S. Patent 2,897,054 and are available through licensing to organizations interested in the conversion of acid sludge.

Additional information on the process may be obtained by writing L. Sonneborn Sons, Inc., 300 Park Avenue South, New York 10, New York.

Report on Moly Bonded Films Available

A new eight-page report, complete with sixteen comprehensive charts, covering moly bonded films has just been released by Bemol, Inc. This technical report presents design information affecting the wear life and frictional properties of moly bonded films.

Subjects covered in this report are speed, load, time, temperature, film thickness, surface finish, surface pretreatment, solid lube type, and bearing hardness. Typical uses, technical data, design tips, and recommendations are included in this report.

The brochure is designed to be used as a working guide for lubrication and design engineers. Copies of this report, entitled "Design Information on Moly Bonded Films," are available from Bemol Inc., 131 State Street, Boston 9, Mass.

New Book Offered

1959 Compilation of ASTM Standards On Petroleum Products and Lubricants D-2

1230 *Pages, Hard Cover,* $9.00

The 1959 edition of the *ASTM Compilation of Standards on Petroleum Products and Lubricants* contains almost 200 standards of which some 45 are new, revised, or have had their status recently changed. The standards have been prepared by ASTM Committee D-2 on petroleum products.

This comprehensive book contains most of the ASTM standards on petroleum including crude petroleum, butadiene, motor and aviation fuels, naphthas, diesel fuels, lubricating oils, industrial oils, cut-

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Copies of this book may be obtained from ASTM headquarters, 1916 Race street, Philadelphia 3, Pa. at $9.00 each.

Battelle Offers Reactor Research Studies

Companies that have previously found it difficult to obtain nuclear reactor irradiations to supplement their own research programs may take encouragement from a recent announcement made by Battelle Memorial Institute concerning the research assistance offered by its nuclear research center. Dr. H. R. Nelson, manager of nuclear research activities, said that the Institute is now prepared to accept a "larger number of requests" from industry for the irradiation of specimens that will be used in research studies conducted by individual companies.

"Battelle," Dr. Nelson observed, "recognizes that the limited availability of reactor space has presented a real barrier for some industrial firms that might otherwise now be engaged in useful atomic research. With the assistance we are now prepared to offer, it is to be hoped that these companies will find an entree into the field of nuclear research. From experience, we have seen that an outlay of from $3,000 to $6,000 for reactor irradiation may provide a company with a whole new area of materials study that may be pursued within the company's existing research organization."

More Than Doubled

The power level of the Battelle research reactor, in operation more than three years, was doubled earlier this year, raising its normal operating level to two million watts. Nelson said this power doubling of the swimming-pool type reactor was a factor in the Institute's decision to broaden the assistance which it could render. "More important," he said, was the "know how" in handling irradiation studies which the Battelle staff has acquired through experience.

The Battelle research reactor is composed of MTR-type aluminum fuel elements in a demineralized water pool approximately 20 feet wide by 40 feet long and 28 feet deep. A highly versatile research tool, the reactor can accommodate a large variety of specimens for irradiations in its six beam tubes up to 8 inches in diameter and in its thermal column with a 3½-foot-diameter vertical and a 5-foot-square horizontal entrance. A hydraulically operated fast-irradiation facility can be used to obtain short-time high-flux irradiations against the face of the reactor's core. The water surrounding the core may, of course, be used as an irradiation location.

In addition to the reactor, the Battelle nuclear center, located just outside of Columbus, includes hot cells, a critical assembly laboratory, and a special laboratory designed especially for studies of plutonium.

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People in the Industry

John V. Starr

Dr. John V. Starr, manager of the products planning division of Esso Standard's petroleum specialties department, died Sunday, December 6, at his home in Cranford, N. J. He had been ill for several months.

He relinquished a directorship in the National Lubricating Grease Institute last summer because of illness. An authority on lubrication products and problems, he was also a member of the American Chemical society, the American Management association and the API. He was 57.

His service with NLGI began in 1954, when he was elected to the board of directors, and continued until his retirement this fall. In 1958 the office of secretary was recreated and Dr. Starr was elected to the position at that time. Although he served on and was chairman of a number of NLGI committees, the accomplishment he was noted for was his chairmanship of and keen interest in establishing the annual production survey, now accepted as one of the Institute's valuable services.

One of Esso's top technical people for many years, Dr. Starr was manager of the company's manufacturing technical service division at Linden, N. J., during most of the 1940's. For five years he was technical assistant to the general manager of East Coast manufacturing.

He moved to Esso's manufacturing department in New York in 1951 as assistant manager of the lubricants and specialties division.

He was graduated from Wabash college in Indiana, his native state, in 1924 and joined Esso's technical service division as a research chemist in 1928, a few weeks after he received a Ph. D. degree in chemistry from Cornell university.

Dr. Starr is survived by his wife, a son and three daughters. Funeral services were held Wednesday, December 9, in Cranford, where he had lived for nearly 25 years.

McCarthy, Jr. Heads Vulcan Containers

Vern I. McCarthy, Jr., 32-years-old, has been named president and director of marketing of Vulcan Containers Inc., pioneer manufacturer of steel shipping containers, it was announced by Vern I. McCarthy, Sr., who moves up from the presidency to chairman of the board.

Mr. McCarthy, Jr., is the third generation of the McCarthy family to serve the company as president. The senior McCarthy will continue to play an active role in long range planning and research, the announcement said.

With the company in an executive capacity since 1953, the new president has served in a number of other posts for more than fifteen years. Prior to this appointment, he was vice president-marketing and director of sales.

The 43-year-old corporation manufactures a wide range of steel shipping pails, drums and tinplate cans ranging in size from one ounce to 55 gallons.

Mr. McCarthy is the youngest man to hold the post of Vulcan president. His father was 40 when he was named president in 1942 and his grandfather, Patrick Henry, was 47 when he founded the company in 1916.

The younger McCarthy brings to his new position a wealth of experience in the steel container field. He is a former deputy director, containers and packaging division, B.D.S.A., Dept. of Commerce, Washington, D.C., (while on leave from Vulcan) and is at present a

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member of the National Defense Executive Reserve and a consultant to the Dept. of Commerce. In addition he is a director of the packaging foundation of Michigan State university.

Mr. McCarthy, Jr., holds either personal or corporate membership in a number of organizations including the Steel Shipping Container Institute, Can Manufacturers Institute, Packaging Institute, American Ordnance association, National Institute of Packaging and Logistics Engineers (Washington, D. C.), Sales-Marketing Executives of Chicago, and the Chicago and National Paint, Varnish and Lacquer Association.

Others are National Lubricating Grease Institute, Independent Oil Compounders association, National Association of Manufacturers, Illinois Manufacturers association, Chicago Association of Commerce and Industry and the National Small Businessmen's association.

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George W. Trainor

George W. Trainor, veteran of the chemical division of Darling & Company, passed away quite suddenly of a heart attack in early November. Mr. Trainor had been Company Representative of this Associate member firm for a number of years and was well known throughout the industry.

Manages Esso Refinery

Frederick C. Westphal, Jr., became manager of Esso Standard Oil company's Bayonne (N. J.) refinery, effective December 1, the company announced. Bayonne is primarily a petroleum-specialties plant.

He has been administrative superintendent of Esso's Bayway refinery, Linden, N. J., for the last year.

As manager at Bayonne, Mr. Westphal will succeed David F. Edwards, who has been invited to join the new Humble Oil & Refining company, a Delaware corporation, as employee relations manager. Standard Oil company (N. J.), Esso's parent company, recently announced plans to consolidate the operations of its major United States affiliates into the new Humble company.

Mr. Westphal joined Esso in 1940 and was assigned to the Bayway refinery in 1953 as assistant chief accountant. He headed the refinery's receiving, packaging and shipping division and later its business service department before he was named administrative superintendent last year.

A graduate of Tulane University, he served as a major in Army Quartermaster operations during World War II.

Assumes New Position

Capital City Products company of Columbus, Ohio has announced the appointment of Mr. Daniel D. Downes as sales manager of the distilled fatty acids division, replacing the late Mr. E. G. Hibarger, who died of a heart attack in early November.

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NLGI MOVIE — "Grease, the Magic Film," a 16-mm sound movie in color running about 25 minutes, now released. First print $300, second and subsequent orders $200 each (non members add $100 to each price bracket).

WHEEL BEARING MANUAL — "Recommended Practices for Lubricating Automotive Front Wheel Bearings." More than 170,000 copies of this booklet have been distributed throughout the world. Now in its sixth printing. Sixteen pages, with more than 40 illustrations. Twenty-five cents a copy, with quantity discounts — company imprint arranged.

PRODUCTION SURVEY — Data on production by pounds of lubricating greases and fluid gear lubricants for NLGI Canadian members (1958) and U. S. members (1957 and 1958) by soap types. Member price for additional copies, $1.00. Non-members, $2.00.

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Lithium hydride can convert carbon dioxide to free carbon . . . can reduce acetyl chloride to acetaldehyde and lithium chloride (illustrated above) . . . can be used to prepare new hydrides which would otherwise be unobtainable except in small yields and by difficult synthesis . . . functions efficiently in many organic condensation and reduction reactions . . . and can easily be increased in solubility or controlled in reactivity by conversion to mixed hydrides.

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Lithium hydride reacts with alcohols to form lithium alcoholates and hydrogen. This reaction makes possible the convenient preparation of anhydrous lithium alcoholate which is useful as an alcoholysis catalyst.

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N_H of lithium hydride is 5.90 compared to 6.68 for water at room temperature. And because of its low dissociation pressure at its melting point (27 mm at 680°C.), lithium hydride can be heated to red heat in a thin-wall container . . . without requiring a pressure shell. It appears to be stable indefinitely at this temperature.

These and many other useful characteristics of lithium hydride may help improve your product or process. For complete technical data, write for Bulletin 102. Address request to Technical Literature Dept., Foote Mineral Co., 402 Eighteen West Chelten Bldg., Phila., 44, Pa.

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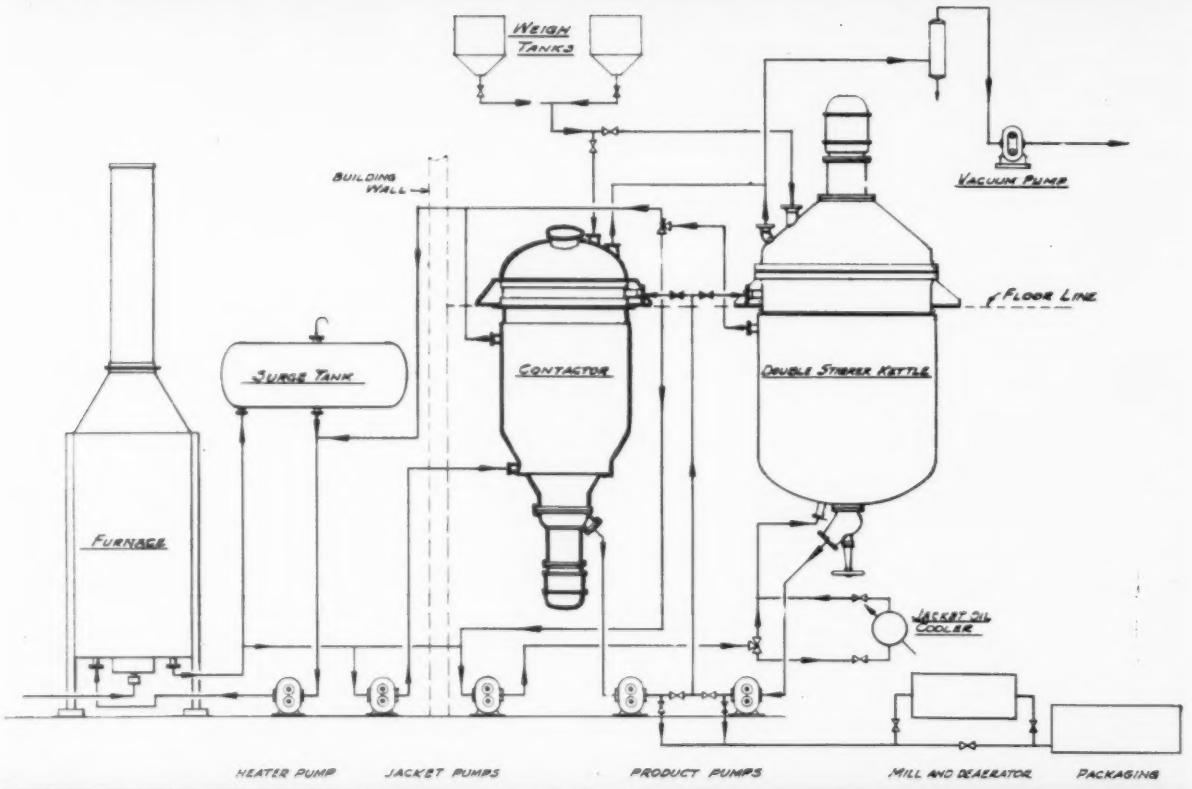

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